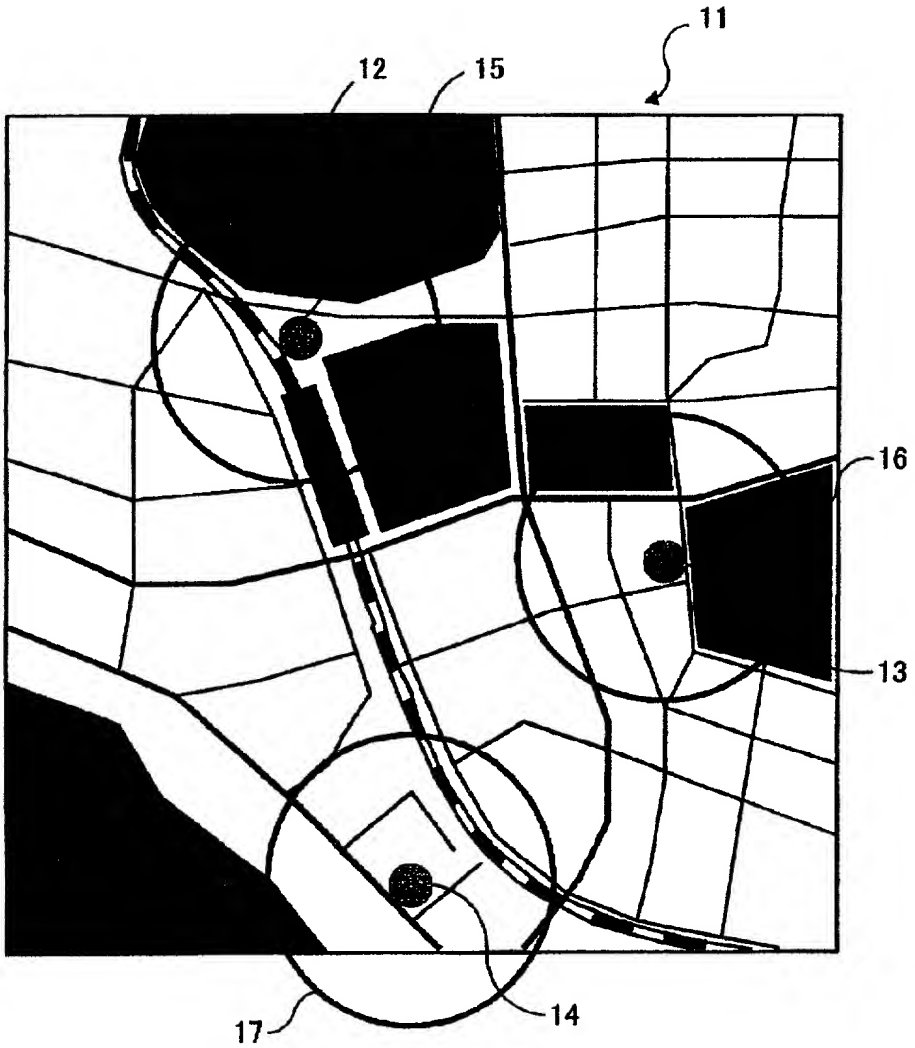


Fig. 1

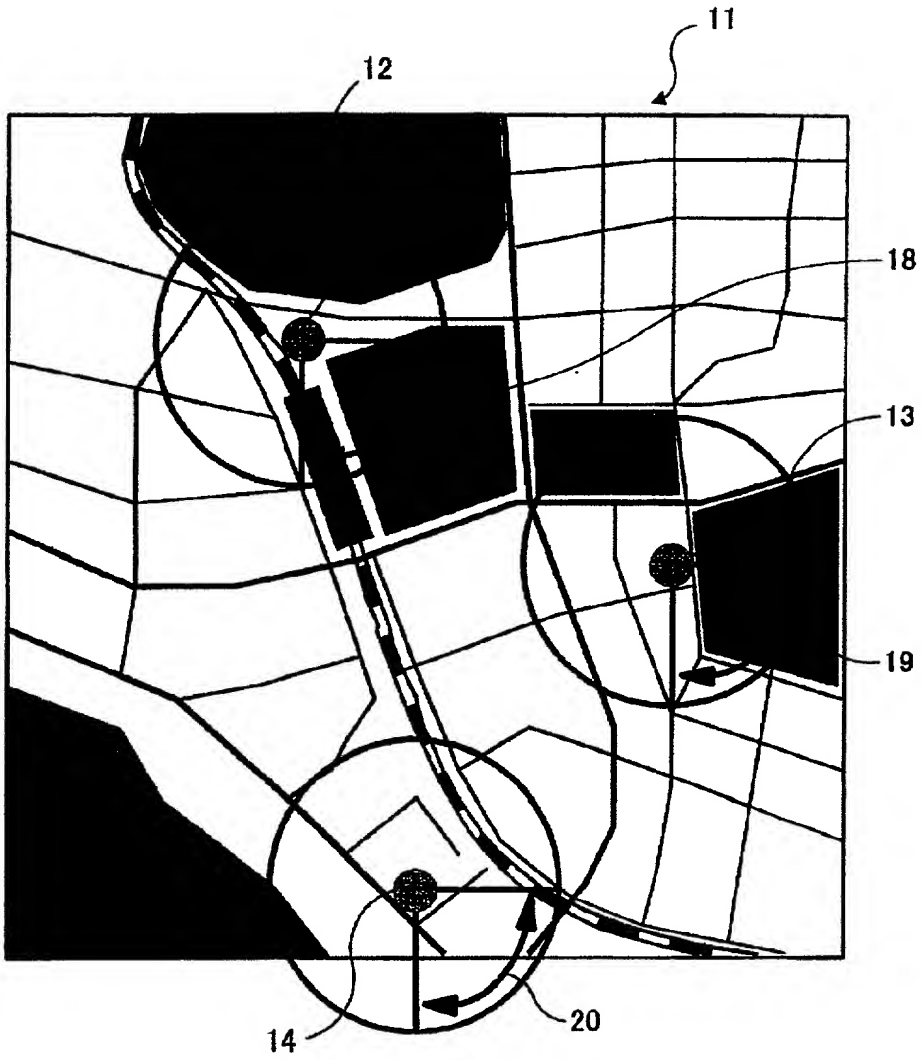


Fig. 2

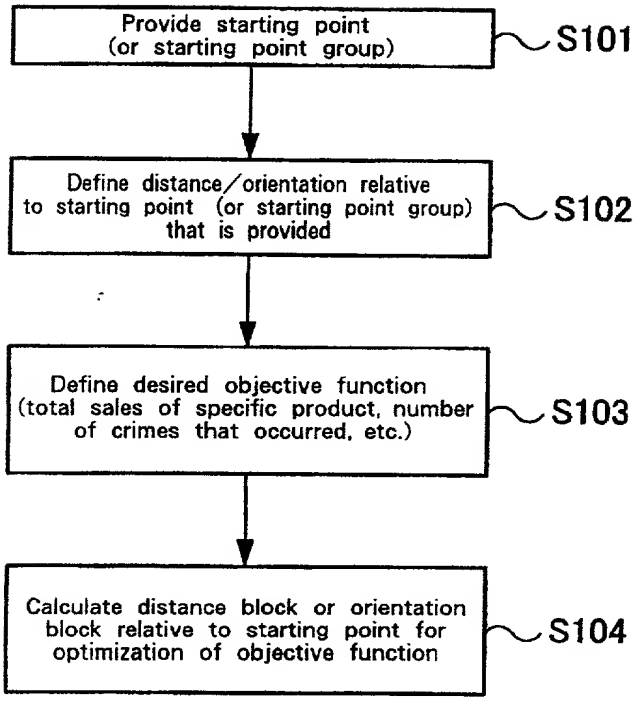

Provide starting point (or starting point group)
S101
Define distance/orientation relative to starting point (or starting point group) that is provided
S102
Define desired objective function (total sales of specific product, number of crimes that occurred, etc.)
S103
Calculate distance block or orientation block relative to starting point for optimization of objective function
S104

Fig. 3

Example database

Post office schema = (ID, position (coordinate), *type*)

School schema = (ID, position (coordinate), *type*)

Police station schema = (ID, position (coordinate), *type*)

Train station schema = (ID, position (coordinate), passenger count, *transfer station or not*)

Convenience store schema = (ID, position (coordinate), sales, *store name*)

Customer schema = (ID, position (coordinate), age, *sex*, annual income, *occupation*)

ATM schema = (ID, position (coordinate), average withdrawal, average operation times)

Crime schema = (ID, position (coordinate), *type*)

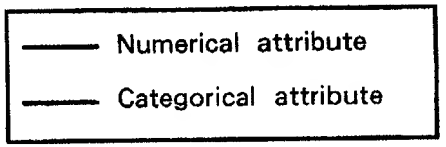


Fig. 4

Define starting point group for distance and origin point group for orientation

Post offices (ALL, types)

Schools (ALL, types)

Police stations (ALL)

Train stations (ALL, X passengers or more, less than X passengers)

Convenience stores (ALL, sales X or higher, less than sales X)

ATM (ALL)

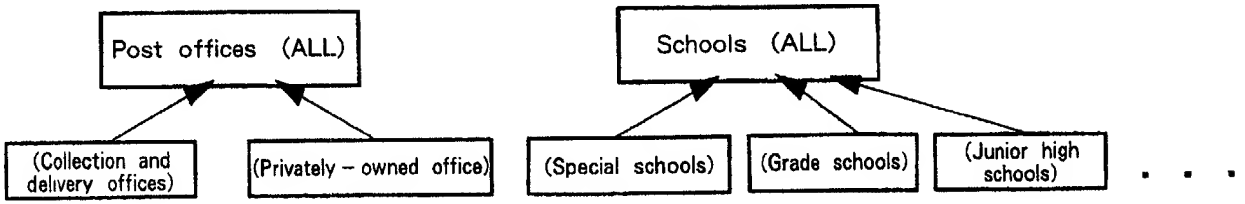


Fig. 5

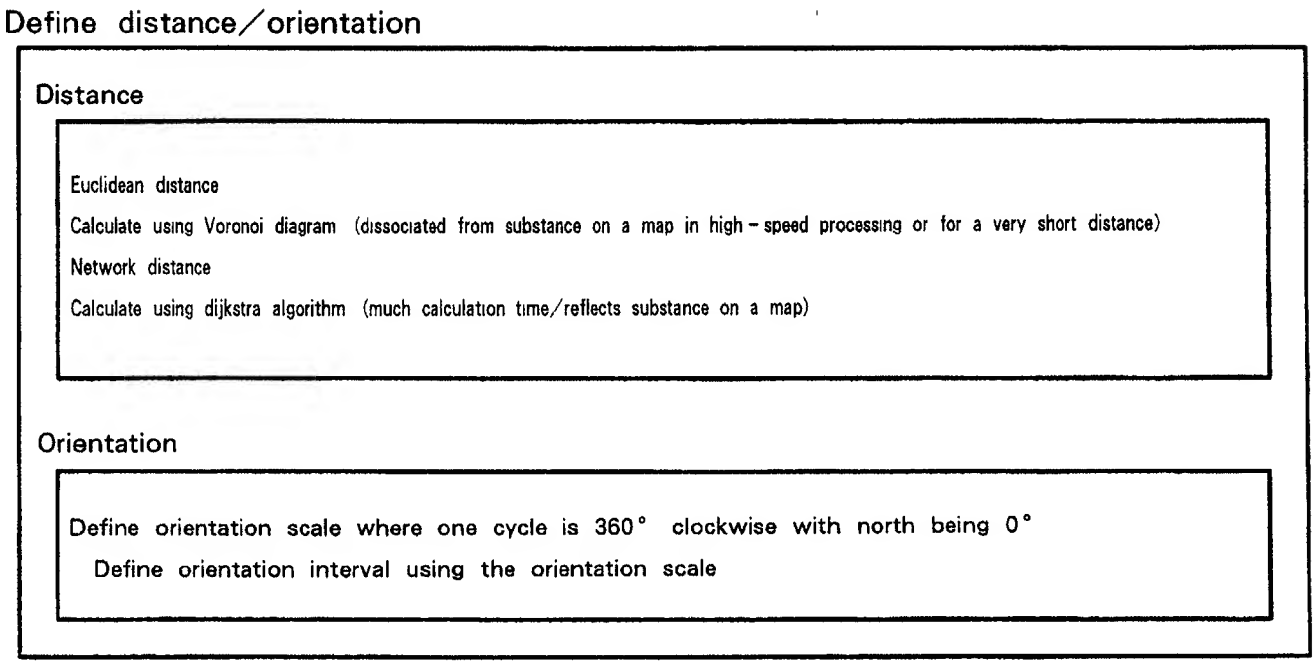

Define distance/orientation
Distance
Euclidean distance
Calculate using Voronoi diagram (dissociated from substance on a map in high-speed processing or for a very short distance)
Network distance
Calculate using dijkstra algorithm (much calculation time/reflects substance on a map)
Orientation
Define orientation scale where one cycle is 360° clockwise with north being 0°
Define orientation interval using the orientation scale

Fig. 6

Define objective function

"Customer schema"
(Maximized distance for the "average annual incomes" of customers having support rate of S or higher)
"Customer schema"
(Maximized distance for customer rates of "*age of 60 or older*" having support rate of S or higher)
"Customer schema"
(Minimized distance for a square error of "average annual incomes")
"Customer schema"
(Maximized distance for mutual amount of "*sex*" information)
"ATM schema"
(Maximized distance for "ATM count/customer count" having support rate of S or higher)

——— Numerical (or derived as numerical value) attribute

——— Categorical (or derived as categorical value) attribute

Fig. 7

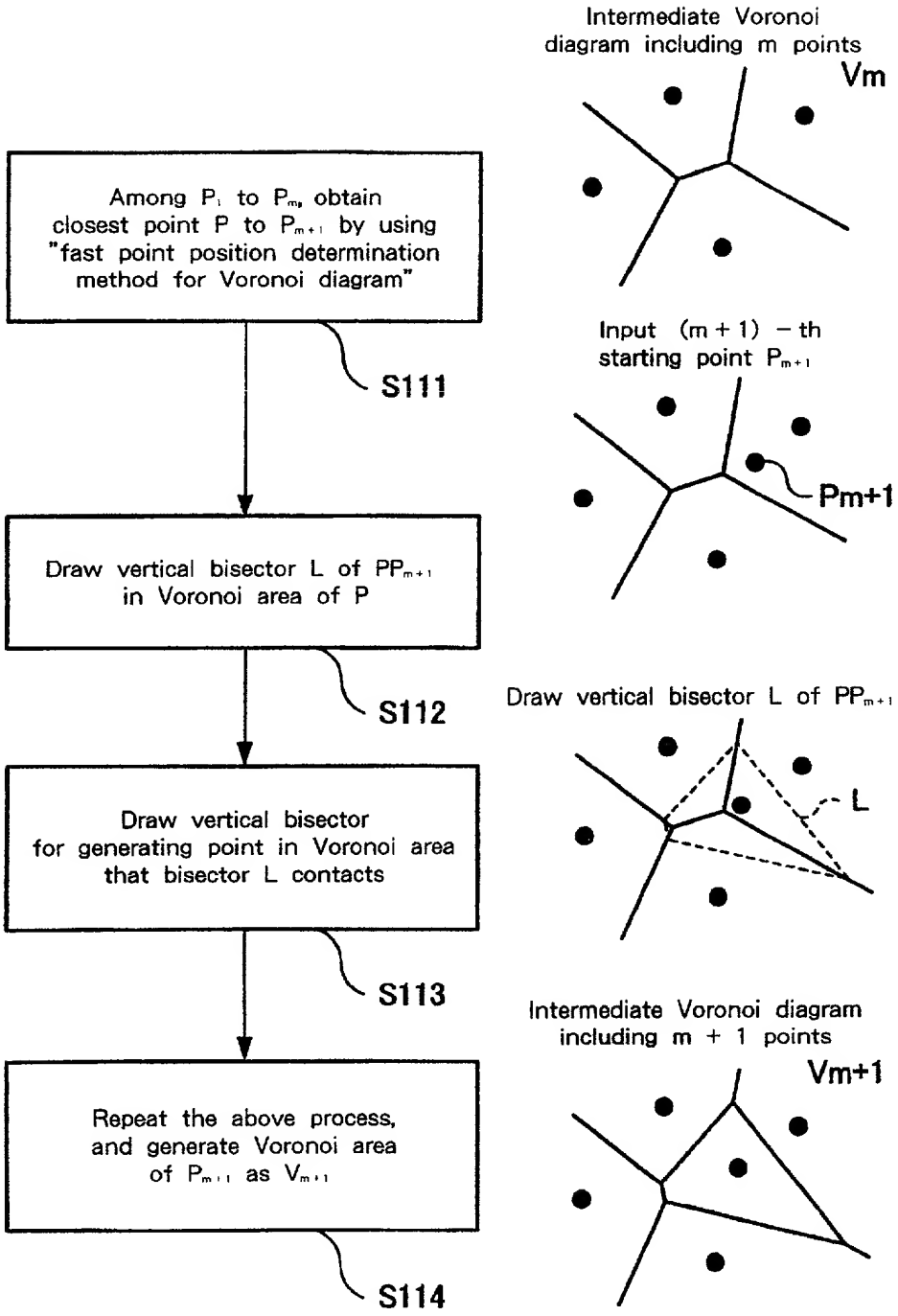

Among P_1 to P_m, obtain closest point P to P_{m+1} by using "fast point position determination method for Voronoi diagram"
S111
Draw vertical bisector L of PP_{m+1} in Voronoi area of P
S112
Draw vertical bisector for generating point in Voronoi area that bisector L contacts
S113
Repeat the above process, and generate Voronoi area of P_{m+1} as V_{m+1}
S114
Intermediate Voronoi diagram including m points
Vm
Input (m + 1) – th starting point P_{m+1}
Pm+1
Draw vertical bisector L of PP_{m+1}
L
Intermediate Voronoi diagram including m + 1 points
Vm+1

Fig. 8

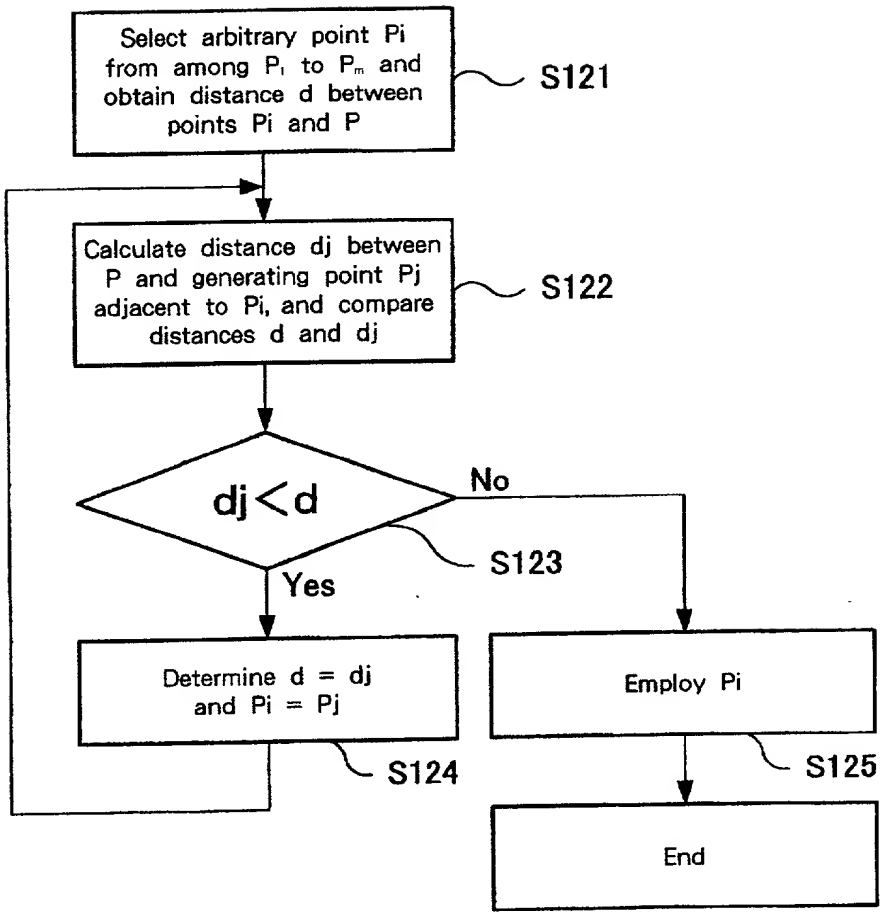
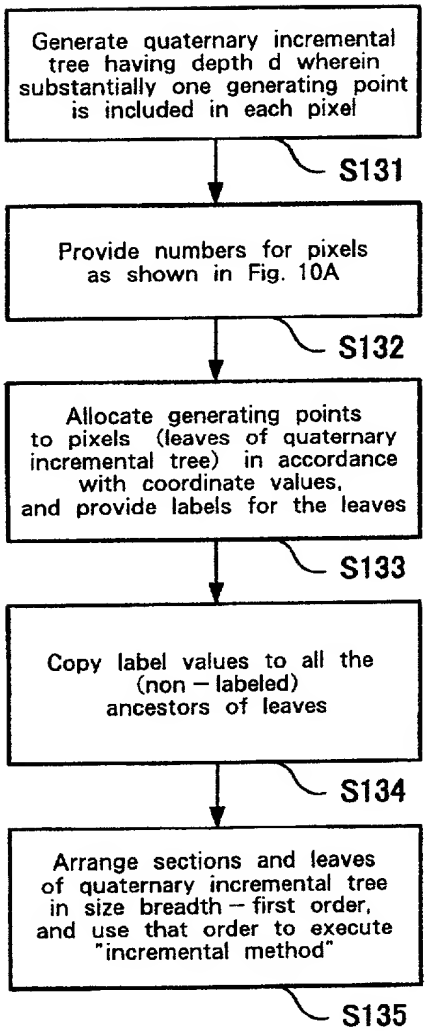
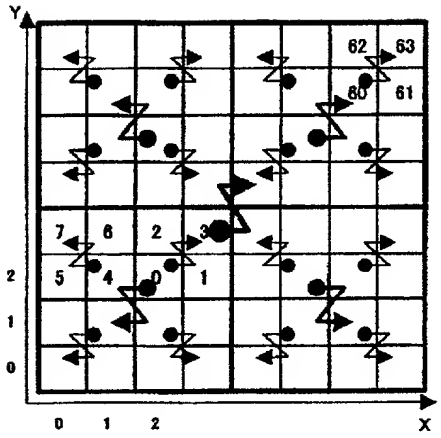
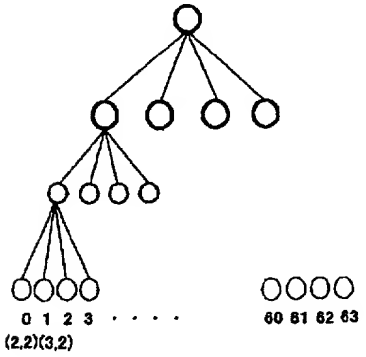

Select arbitrary point Pi from among P1 to Pm and obtain distance d between points Pi and P
S121
Calculate distance dj between P and generating point Pj adjacent to Pi, and compare distances d and dj
S122
dj<d
No
S123
Yes
Determine d = dj and Pi = Pj
S124
Employ Pi
S125
End

Fig. 9





(a) View of map
(two – dimensional plane)



(b) View of quaternary incremental tree

Fig. 10

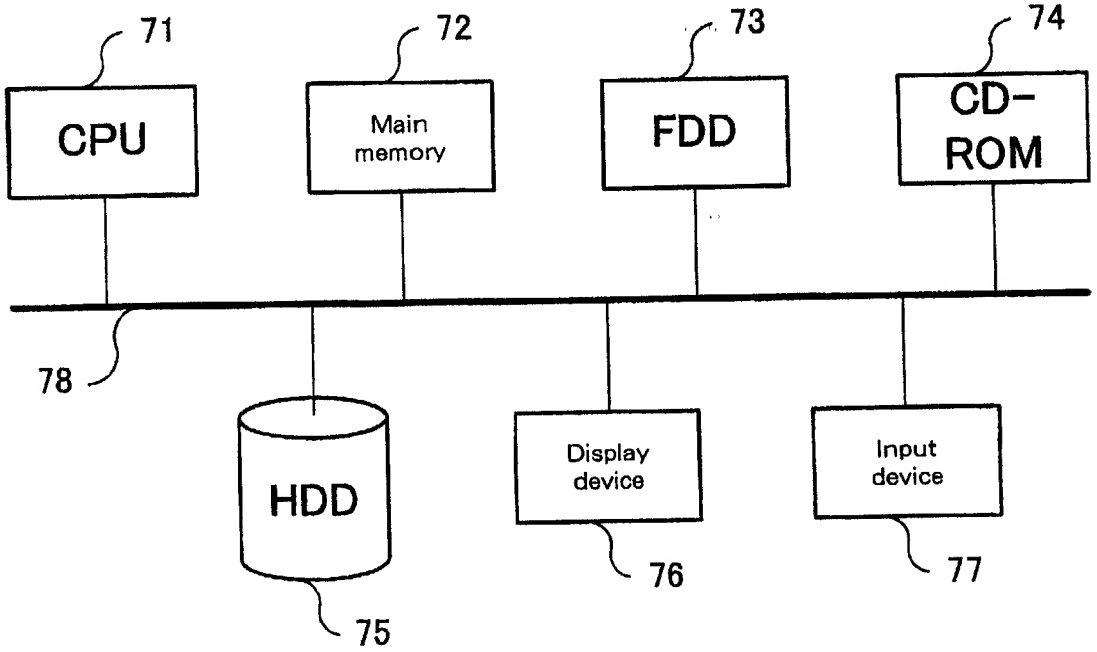

71
72
73
74
CPU
Main memory
FDD
CD-ROM
78
HDD
Display device
Input device
75
76
77

Fig. 11

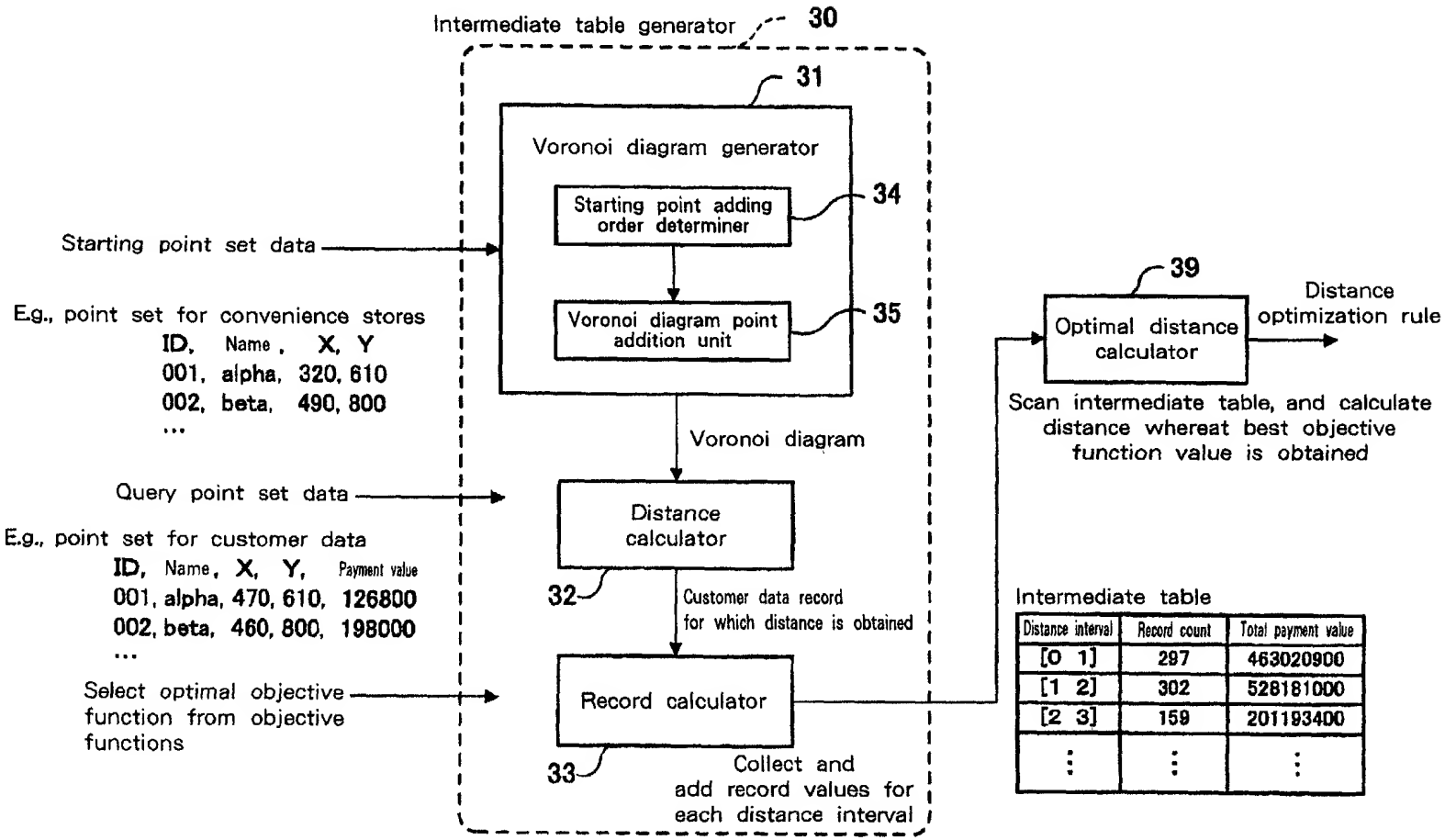

Intermediate table generator
30
31
Voronoi diagram generator
Starting point adding order determiner
34
Voronoi diagram point addition unit
35
Starting point set data
E.g., point set for convenience stores
ID, Name, X, Y
001, alpha, 320, 610
002, beta, 490, 800
...
Voronoi diagram
Query point set data
Distance calculator
32
E.g., point set for customer data
ID, Name, X, Y, Payment value
001, alpha, 470, 610, 126800
002, beta, 460, 800, 198000
...
Customer data record for which distance is obtained
Select optimal objective function from objective functions
Record calculator
33
Collect and add record values for each distance interval
39
Optimal distance calculator
Distance optimization rule
Scan intermediate table, and calculate distance whereat best objective function value is obtained
Intermediate table
Distance interval | Record count | Total payment value
[0 1] | 297 | 463020900
[1 2] | 302 | 528181000
[2 3] | 159 | 201193400

Fig. 12

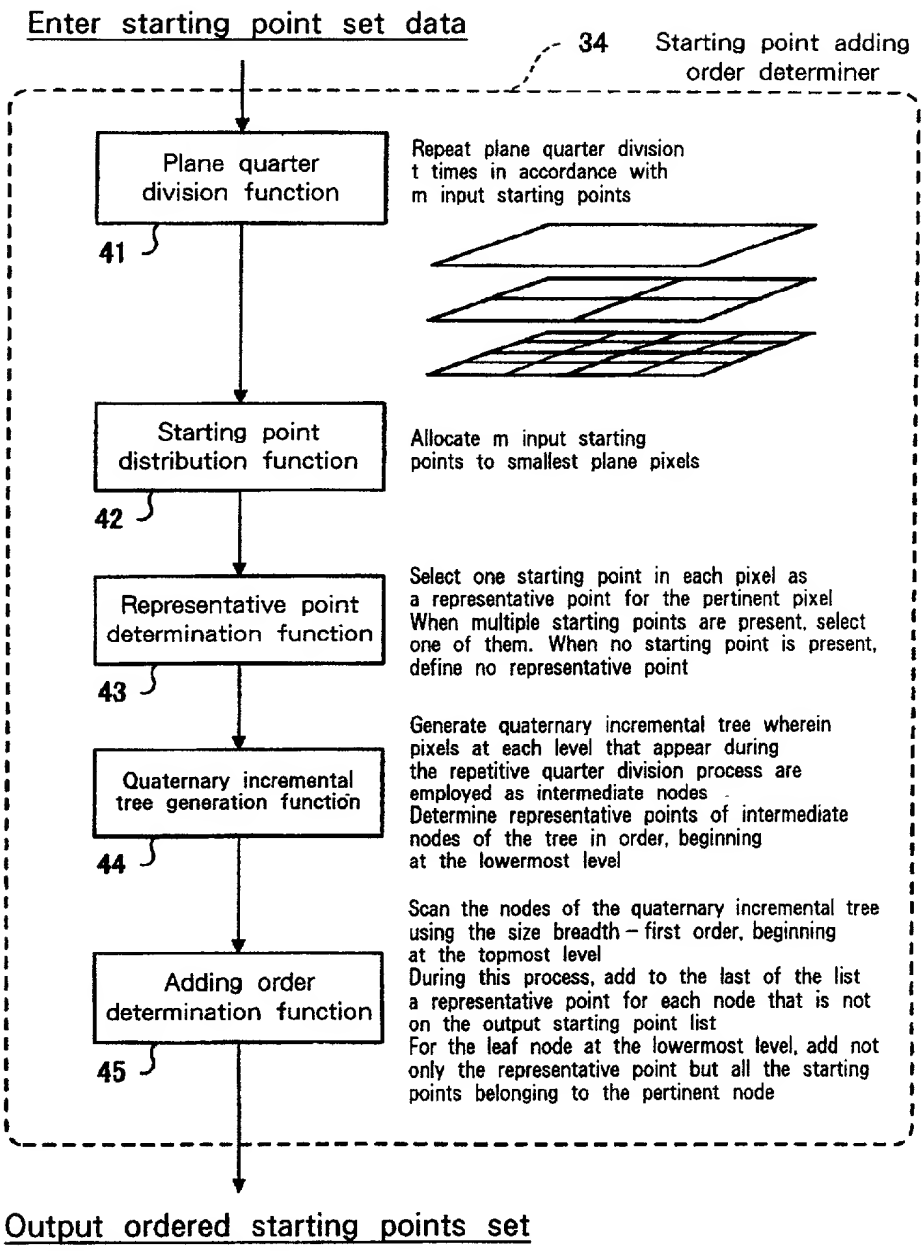

Enter starting point set data
34
Starting point adding order determiner
Plane quarter division function
41
Repeat plane quarter division t times in accordance with m input starting points
Starting point distribution function
42
Allocate m input starting points to smallest plane pixels
Representative point determination function
43
Select one starting point in each pixel as a representative point for the pertinent pixel When multiple starting points are present, select one of them. When no starting point is present, define no representative point
Quaternary incremental tree generation function
44
Generate quaternary incremental tree wherein pixels at each level that appear during the repetitive quarter division process are employed as intermediate nodes . Determine representative points of intermediate nodes of the tree in order, beginning at the lowermost level
Adding order determination function
45
Scan the nodes of the quaternary incremental tree using the size breadth – first order, beginning at the topmost level
During this process, add to the last of the list a representative point for each node that is not on the output starting point list
For the leaf node at the lowermost level, add not only the representative point but all the starting points belonging to the pertinent node
Output ordered starting points set

Fig. 13

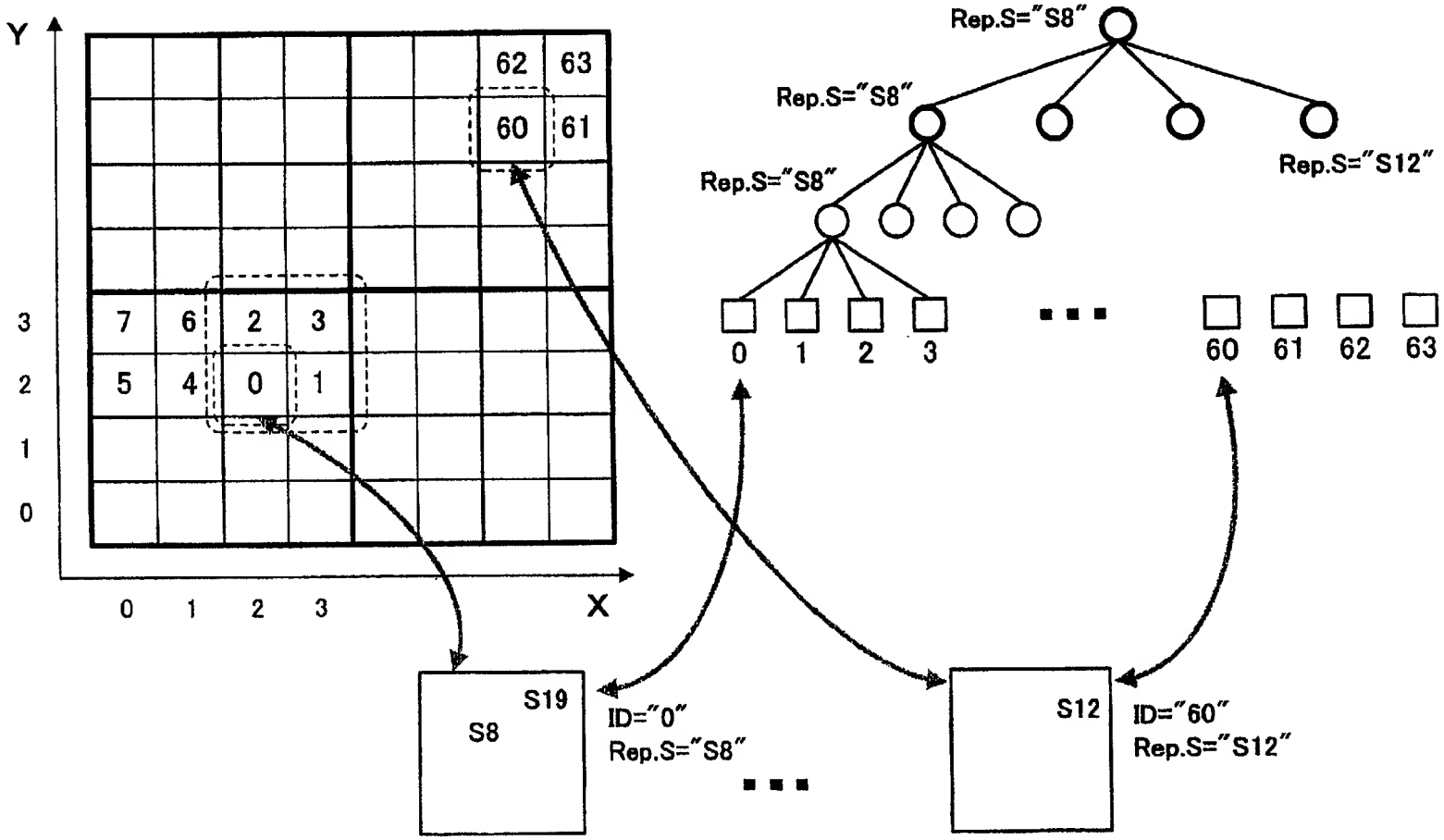

Y
X
0
1
2
3
62
63
60
61
7
6
2
3
5
4
0
1
Rep.S="S8"
Rep.S="S8"
Rep.S="S8"
Rep.S="S12"
0
1
2
3
60
61
62
63
S19
S8
ID="0"
Rep.S="S8"
S12
ID="60"
Rep.S="S12"

Fig. 14

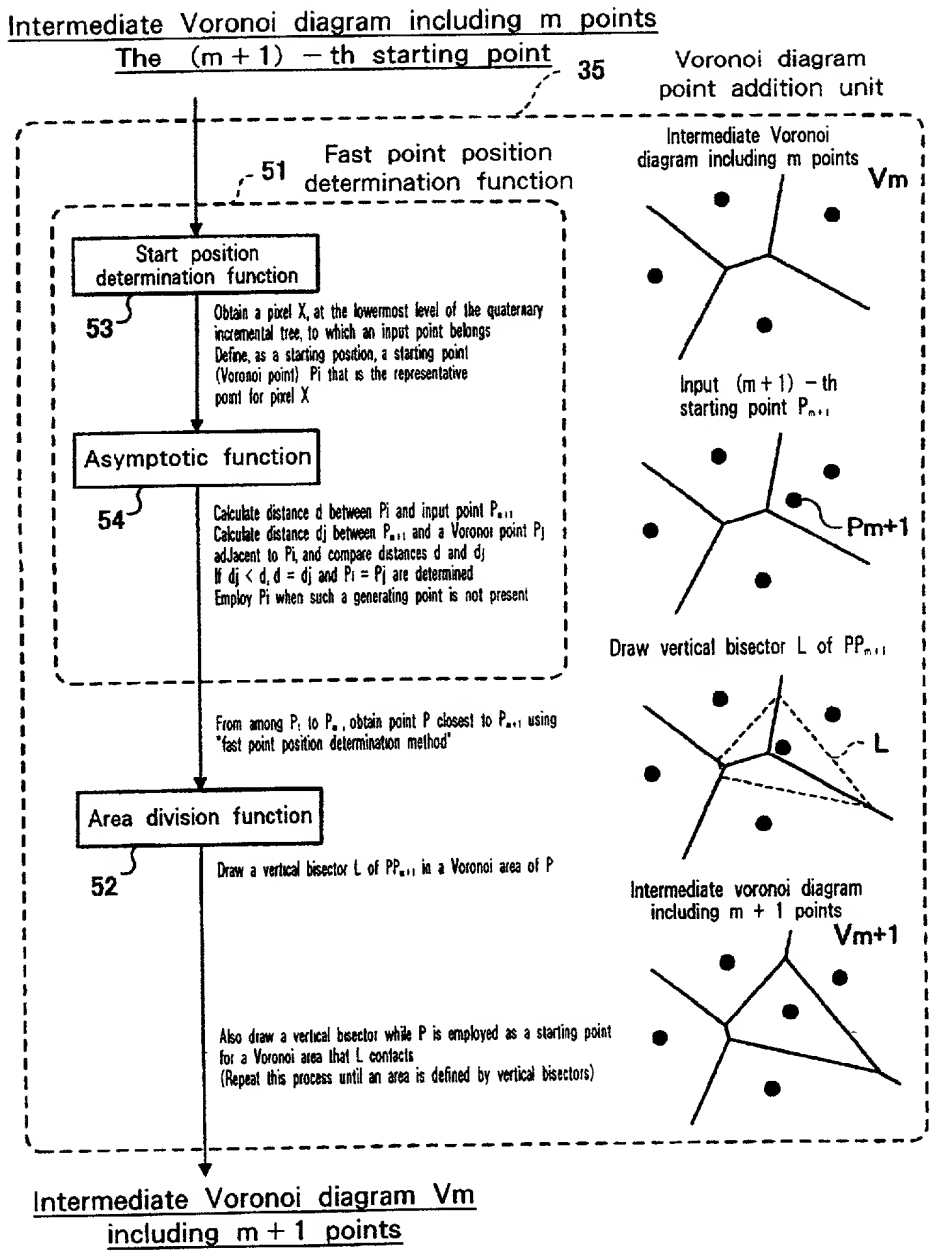

Intermediate Voronoi diagram including m points
The (m + 1) – th starting point
35
Voronoi diagram point addition unit
51
Fast point position determination function
Start position determination function
53
Obtain a pixel X, at the lowermost level of the quaternary incremental tree, to which an input point belongs
Define, as a starting position, a starting point (Voronoi point) Pi that is the representative point for pixel X
Asymptotic function
54
Calculate distance d between Pi and input point Pm+1
Calculate distance dj between Pm+1 and a Voronoi point Pj adJacent to Pi, and compare distances d and dj
If dj < d, d = dj and Pi = Pj are determined
Employ Pi when such a generating point is not present
From among P1 to Pm, obtain point P closest to Pm+1 using "fast point position determination method"
Area division function
52
Draw a vertical bisector L of PPm+1 in a Voronoi area of P
Also draw a vertical bisector while P is employed as a starting point for a Voronoi area that L contacts
(Repeat this process until an area is defined by vertical bisectors)
Intermediate Voronoi diagram including m points
Vm
Input (m + 1) – th starting point Pm+1
Pm+1
Draw vertical bisector L of PPm+1
L
Intermediate voronoi diagram including m + 1 points
Vm+1
Intermediate Voronoi diagram Vm including m + 1 points

Fig. 15